Deriving an Analytical Algorithm for the Localization of Signal Sources in Orb Webs and Other Net Geometries: A Novel Mathematical Approach to Positioning Systems

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When an orb web is impacted by a small object, it is possible for spiders to locate the point of impact exclusively by measuring the propagation of the resulting transversal waves through the net using at least two arbitrarily placed vibration sensors. Commencing from an abstraction of this natural approach to positioning systems, the objective of this project was to develop a mathematical method enabling the localisation of the source E of any linearly propagating signal in a net-like system - given only the time interval ?t between the first arrival of the signal at the sensors, their location D1 and D2, the phase speed c of the signal and the web's topological parameters. Thus, the mathematical theory governing the relationship between those values was derived for non-trivial net geometries. As the determination of the shortest path between two arbitrary points on a net is essential for calculating the ?t resulting from any location of E in an otherwise unchanged parameter configuration, a new analytical solution to this problem was devised for a class of net-like structures of increasing complexity. Through an extensive study comparing the ?t predicted by a simulation based on the previously obtained formulae with experimental values assuming the same E, it was found that with a mean correlation of 87.8%, the derived algorithm is able to predict the location of a signal's source from a measured ?t with a high certainty. This enables applications in a wide range of areas including fiber-optic circuit testing.

Awards Won:

Fourth Award of $500

European Organization for Nuclear Research-CERN: Second Award of $1,500